Clinical Update

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New Advances in Nickel-Titanium Rotary Systems

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Introduction

Since the advent of nickel-titanium (NiTi) rotary systems over two decades ago, new instrument design features have been continually introduced.[1] Although NiTi instruments are now an integral part of endodontic treatment, fracture of these instruments remains a concern.[1] Over the last several years, products have been introduced that use advanced manufacturing techniques to yield more flexible instruments which preserve canal curvature and have better resistance to cyclic fatigue to reduce fracture rate.[2] With new versions of files rapidly introduced, the clinician may find it difficult to choose the file and technique most suitable for an individual case.[1] The purpose of this clinical update is to review the newest endodontic nickel-titanium instrument systems, understand the nature of different NiTi instruments, and how the manufacturer intended them to be used. Although there are many instrumentation systems on the market, this Clinical Update focuses only on those systems that use newer manufacturing techniques to increase file flexibility from Dentsply Tulsa Dental and SybronEndo.

Fracture Mechanism

Despite multiple advantages of NiTi rotary instruments, they have a higher risk of fracture than stainless steel hand instruments.[1] Many variables contribute to file fracture, but the two main causes are *torsional fatigue* and *cyclic fatigue*.[1,3,4] *Torsional fatigue* occurs when an instrument tip locks in the canal while the shank continues to rotate, consequently exerting enough torque to fracture the tip. Typically when this occurs in at risk files prior to fracture, unwinding or straightening of the file can be visualized. If this is observed, the file should be discarded. *Cyclic fatigue*, or flexural fracture, occurs when an instrument is overused and accumulates too much stress in curved canals over time. There are no warning signs and no visible pattern on the file surface.[1,4] Reuse of rotary instruments depends on manufacturer's recommendations, the ability to properly clean surfaces and the assessment of potential defects after clinical usage.[1,5-7] To minimize file fracture, manufacturer's recommendations should be followed with respect to usage.

Thermomechanical Treatment of NiTi Instruments

Over the last decade, studies found that heat treatment of the raw material was effective in increasing flexibility.[8,9] In 2007, M-Wire (Dentsply Tulsa Dental, Tulsa, OK) was developed by applying heat treatments to NiTi blanks, resulting in a controlled memory wire that is used in the production of Profile Vortex, ProTaper Next, Vortex Blue and WaveOne. In 2008, Twisted File (SybronEndo, Orange, CA) was created using a proprietary process during the R-phase to yield a NiTi alloy that can be twisted, instead of milled.[2] The new manufacturing process aims at respecting the molecular structure of the alloy for maximum strength, as opposed to grinding that creates microfracture points during the production of the instruments.[2] M-wire and R-phase treated wire represent the next generation of NiTi alloys with improved flexibility and fatigue resistance.[2,8-10] More information is available in a recently published Clinical Update entitled, " New Developments in Rotary Nickel-Titanium Instruments."[11]

ProFile® Vortex®

Introduced in 2009, Tulsa Dental Specialties (TDS) uses M-Wire for ProFile Vortex rotary files, which yields increased flexibility and resistance to fatigue compared to traditional nickel titanium wire.[12] They are available in ISO tip sizes from 15 to 50, in .04 or .06 taper. They have a rectangular cross section and a recommended rotary speed of 500 RPM.[13]

WaveOne® NiTi File System

In 2011, TDS introduced the WaveOne NiTi file system. It is a single-file system that operates using a reciprocating motion, rather than a rotary motion, in a specially designed handpiece and motor. The manufacturer states that the technique, in most cases, only requires one hand file followed by a single WaveOne file to shape the canal. WaveOne offers the following file sizes:

- The WaveOne Small file for small canals. The tip size is ISO 21 with a continuous taper of 6%.
- The WaveOne Primary file is used in most canals. The tip size is ISO 25 with apical taper of 8% that decreases coronally.
- The WaveOne Large file is used for larger canals. The tip size is ISO 40 with an apical taper of 8% that decreases coronally.[13,14]

The cross-section of the instruments is a modified convex triangular in the apical segment, and convex triangular in the coronal segment.[14] Studies have shown that reciprocating movements are more resistant to torsional and cyclic fatigue compared to continuous rotation.[15,16]

Vortex Blue®

Introduced in 2012, Vortex Blue is manufactured using an advanced thermomechanical process that shows improved fatigue resistance, flexibility and canal centering capability.[2] The proprietary process results in a blue titanium oxide layer giving the system its trademark name. This process has be shown to result in improved surface hardness, improved cutting efficiency, and better wear resistance.[2,12] Vortex Blue is reported to be superior in fatigue resistance and flexibility compared to ProFile Vortex.[12] The manufacturer claims that the proprietary processing of this file reduces shape memory, thus once in the canal, the file follows the natural curvature of the tooth. Vortex Blue is rectangular in cross section and a recommended rotary speed of 500 RPM.[13]

ProTaper® Next™

Introduced in 2013, ProTaper Next files feature variable taper performance, like ProTaper Universal, but adds an off-centered, rectangular cross section for increased file strength as well as progressive tapers with each file. An off-centered rectangular cross-section gives the file a unique asymmetric rotary movement, termed "swaggering." Only two points of the rectangular cross section touch the canal wall at a time, which helps to minimize engagement, maximize debris removal and improve flexibility.[13,17] Due to this system's recent introduction, only limited research is available.

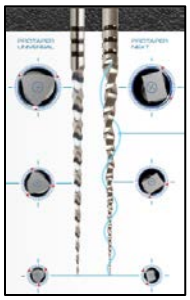

Figure 1. ProTaper Next (right) cross-section, ProTaper Universal (left) cross-section for comparison (Images courtesy DENTSPLY Tulsa Dental Specialties)

All previously mentioned TDS Products are single use only.

Twisted File™

In 2008, SybronEndo introduced Twisted Files (TF). These files are manufactured using a twisted method with a NiTi blank.[18] According to the manufacturer, heat treatment of the alloy allows a temporary phase transformation that allows the nickel titanium alloy to be twisted while in its R-phase.[1,18] Production of the TF cutting flutes via twisting, versus grinding, potentially reduces micro fractures for greater strength. The manufacturer claims R-phase heat treatment delivers strength and flexibility, creating a highly durable and flexible file.[18] TF has a surface treatment to further reduce surface irregularities.[18] Several studies report TF have higher fatigue fracture resistance than files manufactured using a grinding method [3,19-21] and are flexible.[22,23] The instrument was first available with only #25 tip size in tapers from .04 to .12. However, instruments with tip sizes #30, 35, and 40 were recently added.[18] The recommended rotational speed is 500 rpm.[2,24] Studies show that the TF

system preserved the original canal better and had less transportation than the K3 system.[25]

K3XF

Introduced in 2009, K3XF uses R-phase technology to improve on their original K3 system.[18] The result is increased flexibility and ductility giving K3XF better cyclic fatigue resistance compared to K3.[26,27] The manufacturer claims the positive rake angle of K3XF increases cutting efficiency, and the variable helical flute angles aid debris removal from the canal. K3XF is offered in both .04 taper (green) and .06 taper (orange), both which utilize a non-cutting tip and a self-centering feature for added safety.[28]

Twisted File™ Adaptive

SybronEndo's newest file, introduced in 2013, is the TF Adaptive System. This system is designed to be used with an Elements Motor with Adaptive Motion Technology that allows the file to move reciprocally or utilize purely rotational movement depending on the load. TF Adaptive System relies on only 3 files and is color coded similar to a traffic signal.[29] TF Adaptive also uses R-phase technology for increased flexibility. The manufacturer claims that due to the adaptive motion of the file, there is less chance the file will be pulled into the canal.[29] Due to this system's recent introduction, limited research is available.

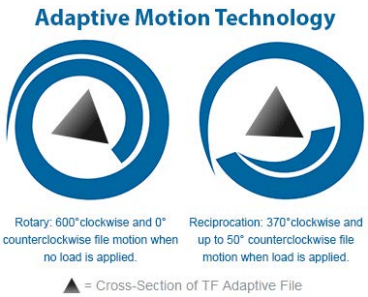

Figure 2. Twisted File Adaptive (Images courtesy of Axis/SybronEndo)
None of SybronEndo files are marked as single use.

Conclusions

Clinicians should be aware that all file systems have benefits and limitations. Ultimately, sound clinical research, clinical experience, proper case selection, handling properties and safety should impact the choice of filing system as opposed to marketing strategies used to promote discussed products.[1] There are other NiTi systems on the market beyond these, and new file systems are introduced frequently. It is imperative that clinicians become familiar with the manufacturer's recommendations prior to use. The product websites may be a good resource for this information. The practitioner should determine a system that is suitable and applicable for the particular case. This is best determined through evidence-based research.

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